Single mode quantum well and quantum dot 50 Gb/s VCSELs for hyperscale datacenter applications

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The number of mobile devices and connections grew to 8.4 billion in 2017 and is expected to grow further as the autonomous driving and the Internet of Things continue to emerge [1]. In view of this growth, the speed and energy efficiency of data processing and data storage becomes very important in modern datacenters. In this context the relevance of the optical interconnects in datacenters increases.

Multimode vertical cavity surface-emitting lasers (MM VCSELs) comprise a well-established solution for short-distance communication through multimode Fiber (MMF). Such systems have low cost, small footprint, high energy efficiency, stability and speed, but their transmission distance is limited to at most ~100 meters at 25 Gb/s due to the chromatic dispersion. Conversely, single-mode (SM) VCSELs allow data transmission over much longer distances because the effects of chromatic dispersion can be drastically suppressed. Recent successes in development of single-mode VCSELs open an opportunity to apply them for data transmission over km-long MMF distances at very high rates, in applications where previously only 1.3–1.5 μm edge-emitting lasers coupled into single-node fibers were used.

In this work we review state-of-the-art 50 Gb/s VCSEL technology in the context of the long-distance data transmission. We present design concepts that allow fabrication of SM VCSELs based on quantum wells and quantum dots, address their temperature stability, and demonstrate the influence of the spectral composition on the transmission distance.

We discuss different modulation formats and the related maximum bit rates that can be achieved using SM VCSELs. Current state-of-the-art high-order modulation formats enable bit rates of 160 Gb/s per single VCSEL [2]. Finally we discuss a method to achieve bit rates of 200 Gb/s and above per single MMF using SWDM of 850 nm, 880 nm, 910 nm and 940 nm lasers operating in non-return-to-zero (NRZ) and pulse-amplitude modulation (PAM) formats.

Combination of these technologies paves the way towards Tb/s data transmission over single multimode fiber in the coming years.

1. Cisco Visual Networking Index (VNI) Global Mobile Data Traffic Forecast, 2017.
2. C. Kottke, C. Caspar, V. Jungnickel, R. Freund, M. Agustin, and N. Ledentsov, "High-speed 160 Gb/s DMT VCSEL transmission using pre–equalization", presented at *Optical Fiber Commun. Conf.* (2017), paper W4I.7.